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SELECTED CYCLES IN GYMNOCONIA PECKIANA

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At the present time *Gymnoconia peckiana* is one of the most interesting species of the rust fungi. As a result of Tranzschel's cultures it was generally accepted as a short-cycle species with two generations in the complete life history. A disquieting factor was introduced when Kunkel presented the results of his studies on the germination of the aecidiospores, demonstrating a still shorter cycle, since the aecidiospores germinated in the manner normal for teleutospores, *i. e.*, by the production of promycelia and sporidia.

This seeming contradiction in the diverse accounts of the life history of *Gymnoconia peckiana* was interpreted in different ways. Some students suggested that the aecidiospores could germinate in either one of two ways. First, under certain conditions they might germinate in the usual way for aecidiospores, by the production of an infection tube, forming a di-energed mycelium in the host, terminating in the formation of teleutospores, thus presenting a *two-generation cycle*. Second, under other conditions the aecidiospores might assume the functions of teleutospores by germinating with promycelium and sporidia, thus presenting a *one-generation cycle*, of course leaving the spermogones out of consideration.

According to another interpretation, these two different cycles represented two distinct specific, or generic, entities. In these two entities, the aecidial stage of the one-generation cycle and the aecidial stage of the two-generation cycle were morphologically indistinguishable, though specifically distinct. The morphological identity of the aecidial stage of both cycles has been demonstrated by Kunkel in a more recent paper, though I do not understand that he has expressed any opinion as to whether or not the one-generation form is specifically distinct from the two-generation form.

A few years after Tranzschel's cultures, indicating the genetic connection of *Caeoma interstitialis* with *Puccinia peckiana* in Russia, as a matter of personal curiosity I transplanted to the greenhouse some raspberry plants which were free from the Caeoma. On these I sowed a large quantity of the aecidiospores of *Caeoma nitens* Schw. In the course of six weeks pustules of *Puccinia peckiana* appeared on a few of the leaves. No further attention was given to observations on this rust until June, 1915.

As a result of Kunkel's studies, I was led to test the germination of the aecidiospores in the vicinity of Ithaca, N. Y. In the suburbs of Ithaca, on Cornell Heights along Fall Creek Drive, there has existed for a number of years a rather large patch of the common dewberry (*Rubus villosus* Ait.), which for several years has been very badly affected with this rust. Aecidiospores from the leaves were dusted on the surface of water in several glass vessels, ranging from 10 to 20 cm. in diameter. The spores were so numerous that they formed a dense orange-yellow layer on the surface of the water. In eighteen to twenty-four hours vast numbers of the aecidiospores had germinated with typical promycelium and sporidia. Similar sowings of aecidiospores from the same patch of dewberry plants were made during the month of June, 1915, with the same results.

Some interesting observations were made at that time on the germination of some large aecidiospores. These aecidiospores germinated in two ways. In some cases two distinct promycelia, each bearing four sporidia, issued from each aecidiospore. In other cases a single germ promycelium issued from the aecidiospore, and at a short distance branched into two promycelia each bearing four sporidia. Similar large aecidiospores were found to contain four nuclei, while those of ordinary size contain but two. We are warranted, therefore, in drawing the inference that the four nuclei in the large aecidiospores represent two conjugate pairs of nuclei.

Early in the spring of 1915, I obtained from a nursery in Geneva, N. Y., several young raspberry and blackberry plants free from the disease. These were potted and the pots sunk in the ground in the partial shade of some trees on the south side of my office. Aecidiospores from the dewberry plants were sown on some of these experimental raspberry plants, on which new shoots were just appearing, many of the aecidiospores falling on the soil close against the stems. No evidence of any infection was observed during the season of 1915, either in the form of Caeoma pustules or of teleutospores. In June, 1916, however, one new shoot from one of the raspberry plants bore several leaves with the caeoma richly developed. Apparently the mycelium did not extend to other parts of the system and become perennial, for there was no evidence of the Caeoma in 1917, on any of these experimental dewberry plants.

One of the important problems still awaiting attack was the question as to whether or not the raspberry Caeoma with the one-generation cycle is biologically the same as the raspberry Caeoma with the two-generation cycle. Tropical and subtropical regions appear to be richer in rusts with the *Endophyllum* type of germination than do the temperate or subarctic regions. *Caeoma nitens* has long been known to have a much farther southern distribution than *Puccinia peckiana* and the recent interesting paper by Arthur clearly shows this. In consideration of these facts, an experiment was made, in June, 1917, on the supposition that temperature might be, to a large extent, the controlling factor, determining the mode of germination of the aecidiospores of the orange rust of the raspberry. This was taken as a working hypothesis, and the following experiment was carried out.

Four of the experimental raspberry plants were sprayed with water. Aecidiospores from the dewberry plants of the same patch mentioned above were dusted on the leaves. This was done June 27, 1917. Excelsior was packed close around the raspberry plants to support several blocks of ice. Each plant with its ice pack was then covered with a bell jar. These experiments were started at 5:30 P.M. The ice was not all melted in twenty-four hours. More ice was added on the afternoon of June 28, and additional aecidiospores were sown. The plants remained covered until the morning of June 30, when the bell jars and excelsior were removed.

The plants were not closely examined again until August 2, 1917. All four of the hosts showed infection. There were several leaves on each plant with yellowish spots and areas, bearing on the under side the minute projecting masses of teleutospores of *Gymnoconia peckiana*. On some of the smaller leaflets the sori were rather thickly scattered over the entire under surface. The teleutospores examined presented in a striking way the peculiar form characteristic of *Puccinia tripustulata* Pk. (24th Rept. N. Y. State Mus. Nat. Hist., 91, pl. 3, fig. 16, 1872).

During the last week in August, 12 to 15 more leaves on the four experimental plants were found to be richly sprinkled with the teleutosori.

The check raspberry plants were close beside those in the chilled atmosphere under the bell jars. No attempt was made to keep the aecidiospores from falling on them. In fact some of their leaves were well dusted with aecidiospores, but on none of them did teleutosori appear. For several years I have examined the dewberry plants, in the patch where the Caeoma is so abundant, for teleutosori and have never been able to find any. If the normal history of the Caeoma on these dewberry plants was a two-generation cycle, one would expect to find, on the leaves of the shoots which have outdistanced the perennial mycelium, some teleutosori.

The production of teleutosori on those plants surrounded by a chilled moist atmosphere during the period when the aecidiospores were germinating indicates that, because of the lowered temperature, the aecidiospores, or at least many of them, did not germinate by a promycelium, but by an ordinary germ tube, which entered the host leaf forming a diploid mycelium from which the teleutospores arose. Germination of the aecidiospores of *Caeoma nitens*, therefore, appears to be selective, the mode of germination being determined by temperature conditions. When the temperature is comparatively high, they assume the function of teleutospores.

Gymnoconia peckiana, therefore, is an interesting example of a species in which the life cycle is not permanently fixed. In its more southern distribution, where the temperature, at the time of germination of the aecidiospores, is comparatively high, it is generally (perhaps always) a one-generation cycle species. In its more northern distribution it is often, perhaps usually, a two-generation cycle species. In the intermediate region it has sometimes a one-generation cycle, at other times a two-generation cycle, probably depending on the local and seasonal temperatures at the time of germination of the aecidiospores. The general areas of distribution are, in general, well shown by Arthur, though germinations of the aecidiospores have not been tested over the entire area. Central New York lies in the intermediate climatic zone of the distribution of the species. On the ground of the determinating influence of temperature in the selection of a one-generation or two-generation cycle we would expect the existence here in the vicinity of Ithaca, N. Y., of both cycles. Observation over a period of years has shown that in certain years *Puccinia peckiana* is not uncommon, while in other years it apparently is very rare. No attempt has been made here to correlate the abundance or scarcity of the *Puccinia peckiana* in different years with the temperature conditions. But it would seem reasonable to expect that when comparatively low temperatures prevail during the period of germination of the aecidiospores, *Puccinia peckiana* would be more abundant, other conditions being equal, and conversely there would be a scarcity of the teleuto stage during years when the temperatures in June and early July were comparatively high.

It will be readily seen that the lack of fixity of the generation cycle in *Gymnoconia peckiana* has an important bearing on the principle, recently adopted by some uredinologists, of recognizing the different generation cycles as representing distinct generic concepts. According to the usual practice, which is also in conformity with the International Code, the *Gymnoconia peckiana* would apply not only to the species in its two-generation cycle, but also in its one-generation cycle. For the aecidial stage alone, if one desired to employ a name which would not include the concept of the teleutospore stage, we have the form species name, *Caeoma nitens* Schw. (or *Caeoma interstitialis* Schlecht.). Common practice as well as the International Code permits this use and there is no necessity for a new generic name to apply to the one-generation form of *Gymnoconia peckiana.*

One of the recent practices in uredinology which has many followers in the United States, and which leads to unnecessary confusion, is the new nomenclature applied to the spore conceptacles, or spore pustules, and also to the spores. According to this new principle, the criterion of morphological structures is not their forms nor place in the cycle, but their cytological behavior. It is always very clear, on the basis of the morphological principle, what the aecidia, or aecidiospores, of *Gymnoconia peckiana* are, and the same is true of the teleutosori and teleutospores. On the basis of the new or cytological principle, the morphological aecidium becomes a cytological *aecium* at comparatively low temperatures, but at comparatively high temperatures it becomes a cytological *telium*, or rather a cytological *aecidioid telium.*

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